



(12) **United States Patent**
Lee

(10) **Patent No.:** **US 9,412,464 B2**
(45) **Date of Patent:** **Aug. 9, 2016**

(54) **SEMICONDUCTOR MEMORY DEVICE AND
MEMORY MODULE HAVING
RECONFIGURATION REJECTING
FUNCTION**

USPC 365/201, 96
See application file for complete search history.

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/642,974**

(22) Filed: **Mar. 10, 2015**

(65) **Prior Publication Data**

US 2016/0055920 A1 Feb. 25, 2016

(30) **Foreign Application Priority Data**

Aug. 19, 2014 (KR) 10-2014-0107756

(51) **Int. Cl.**

G11C 29/14 (2006.01)
G11C 17/18 (2006.01)
G11C 17/16 (2006.01)
G11C 29/04 (2006.01)
G11C 29/00 (2006.01)
G11C 29/12 (2006.01)
G11C 7/10 (2006.01)

(52) **U.S. Cl.**

CPC **G11C 17/18** (2013.01); **G11C 17/16**
(2013.01); **G11C 29/04** (2013.01); **G11C 29/12**
(2013.01); **G11C 29/14** (2013.01); **G11C 29/70**
(2013.01); **G11C 7/1054** (2013.01); **G11C**
7/1081 (2013.01)

(58) **Field of Classification Search**

CPC G11C 29/04; G11C 29/12; G11C 29/14

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(57) **ABSTRACT**

A semiconductor memory device and a memory module have a reconfiguration preventing function. The semiconductor memory device may include a memory cell array, a test information storing unit, and a control unit. The control unit may include a control signal storing unit and may prevent programming of the test information storing unit according to a control signal stored in the control signal storing unit.

20 Claims, 13 Drawing Sheets

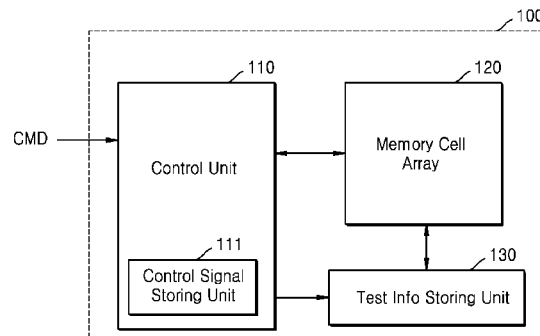


FIG. 1

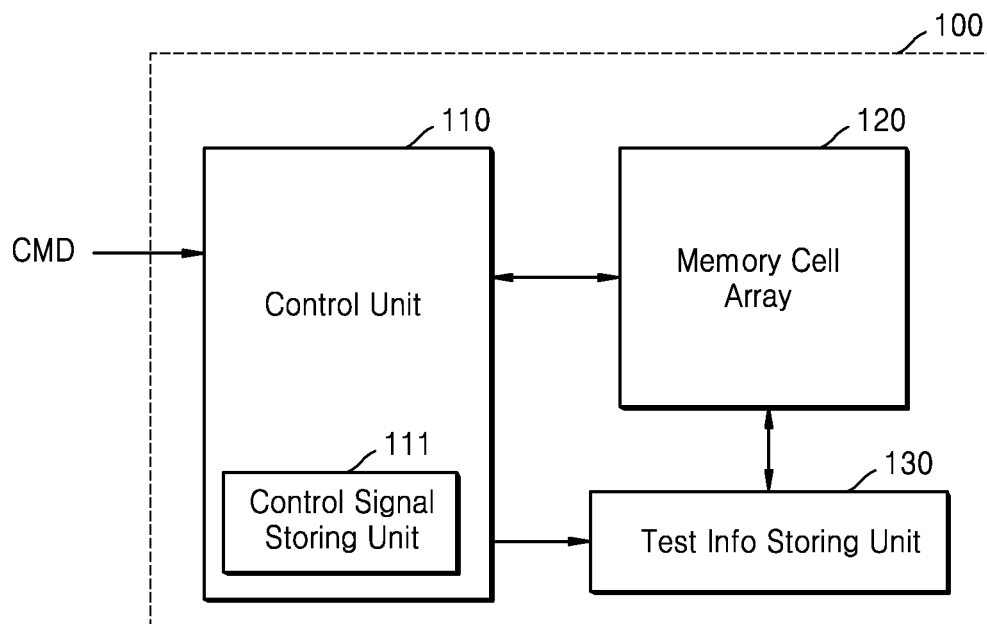


FIG. 2

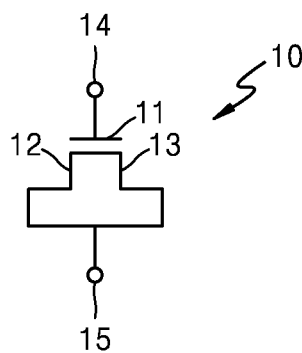


FIG. 3

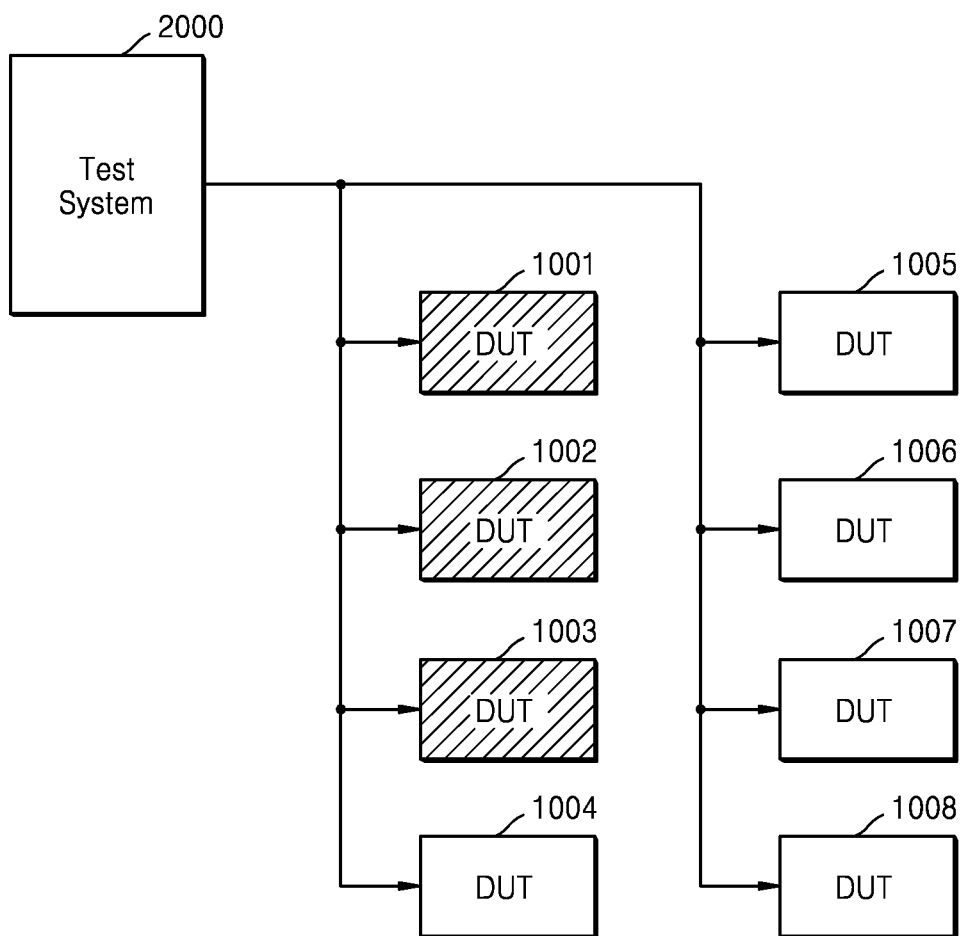


FIG. 4

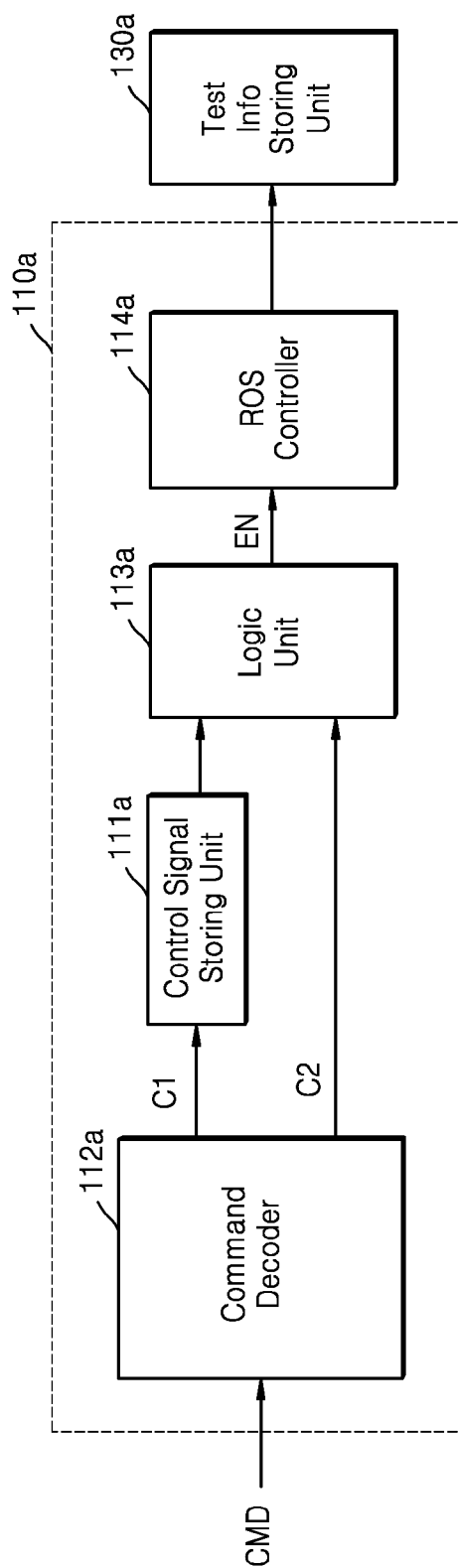


FIG. 5

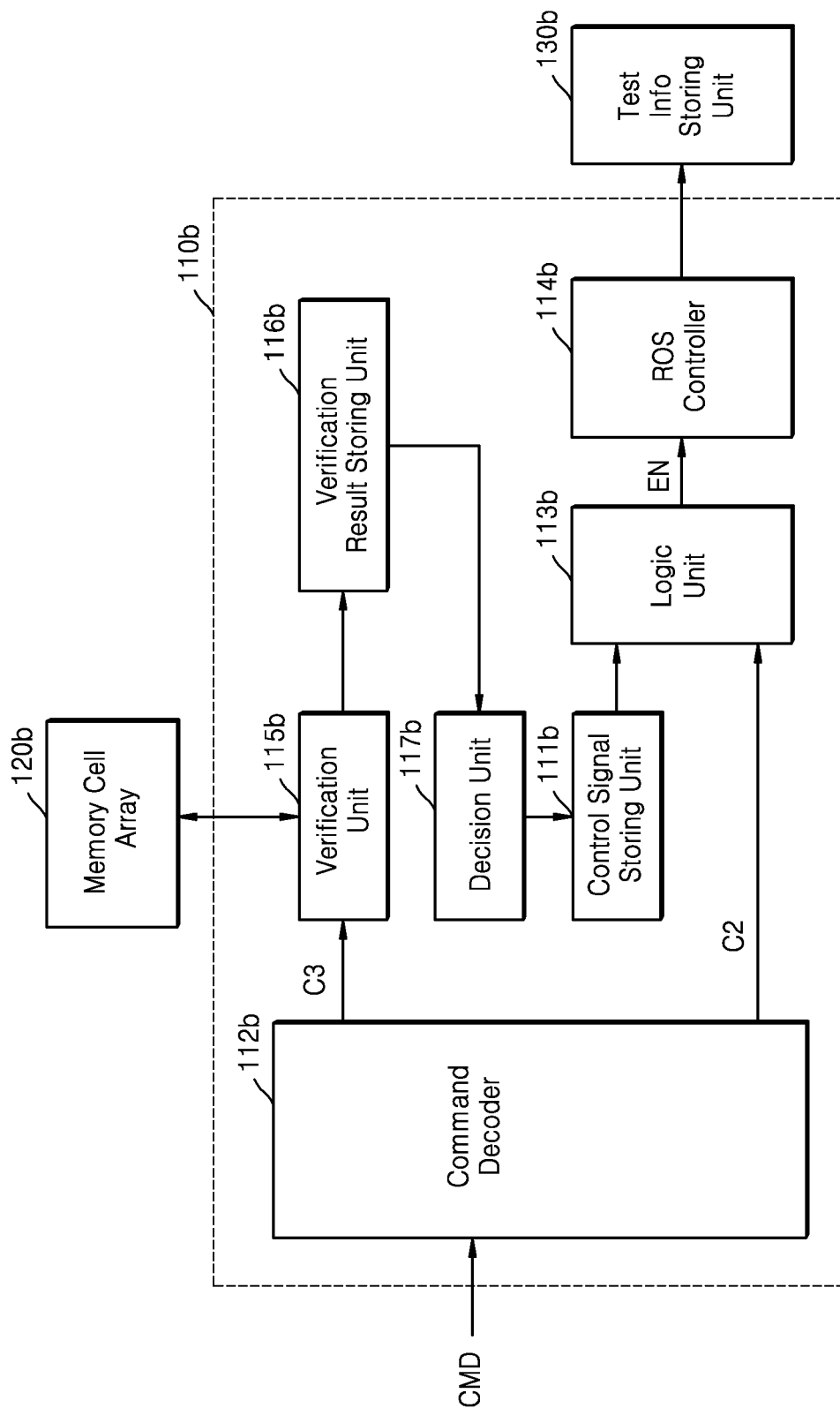


FIG. 6

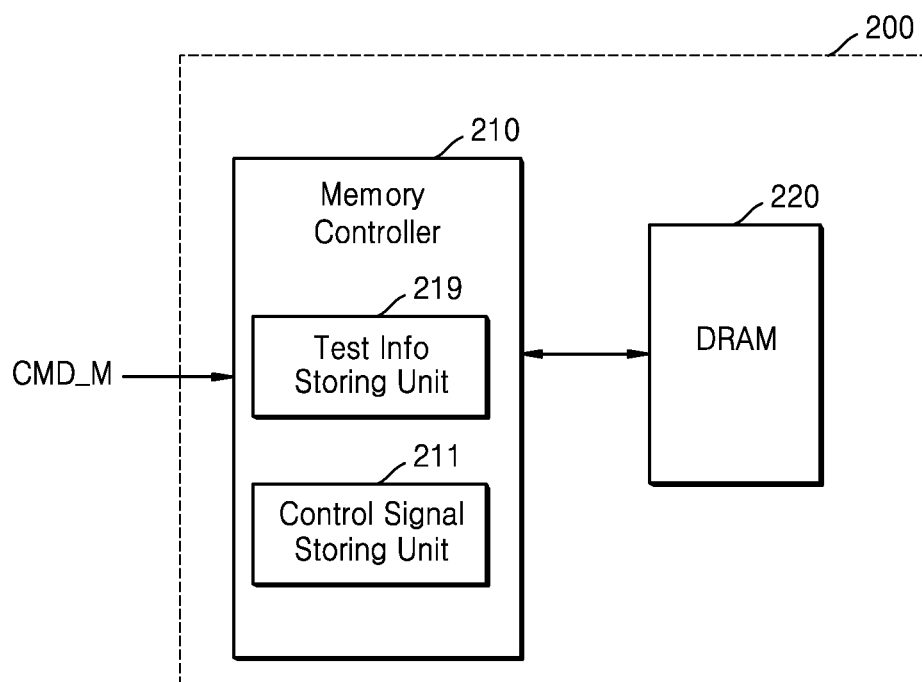


FIG. 7

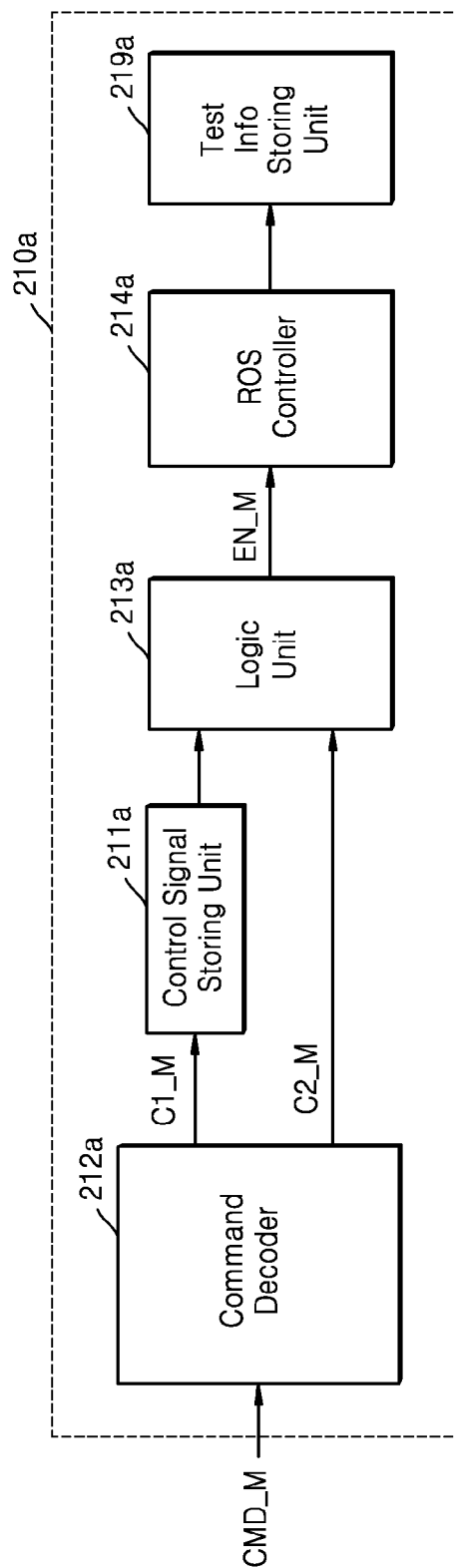


FIG. 8

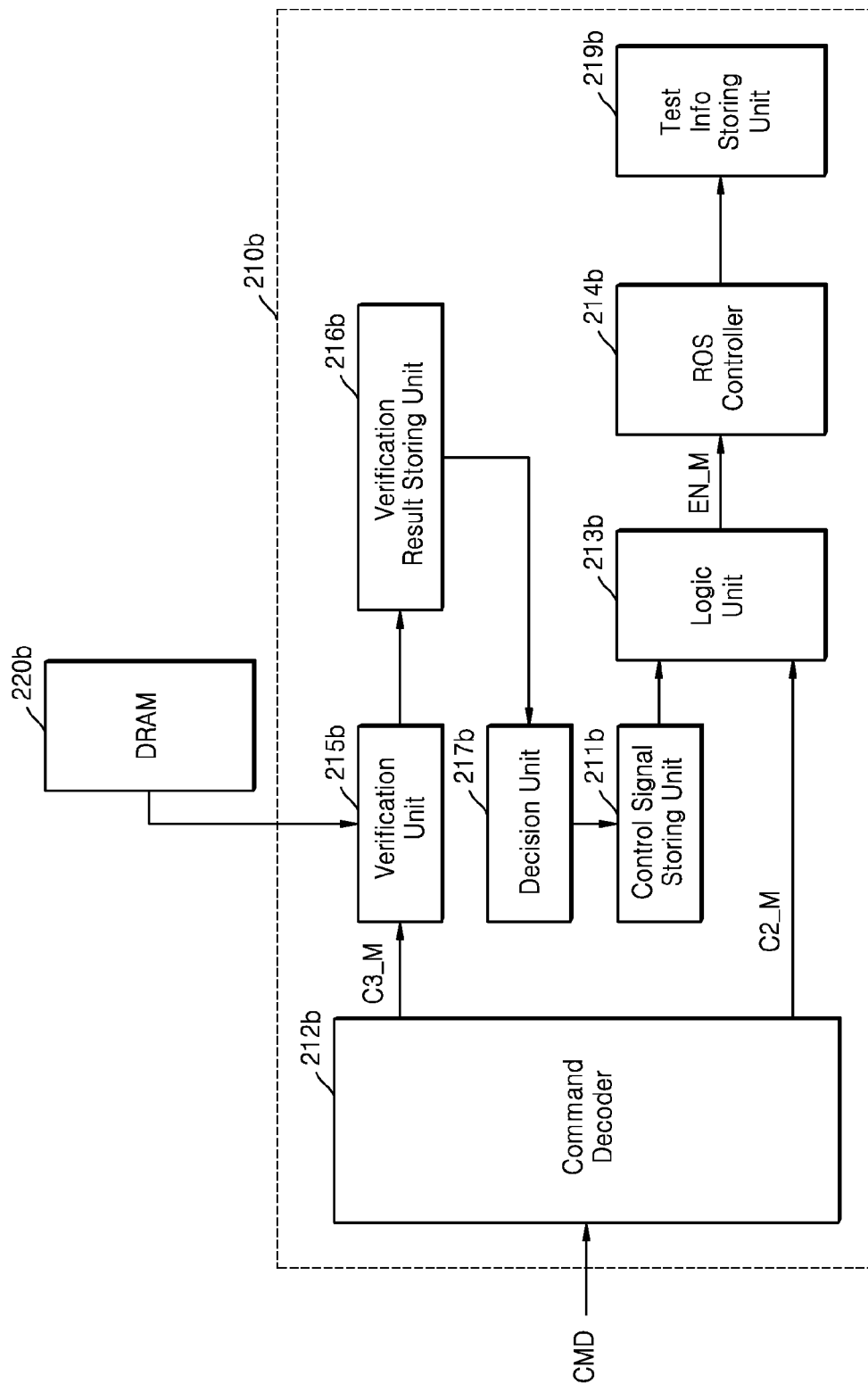


FIG. 9

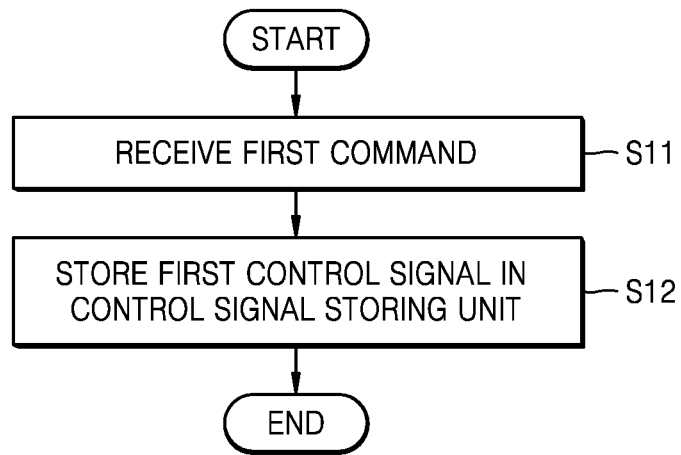


FIG. 10

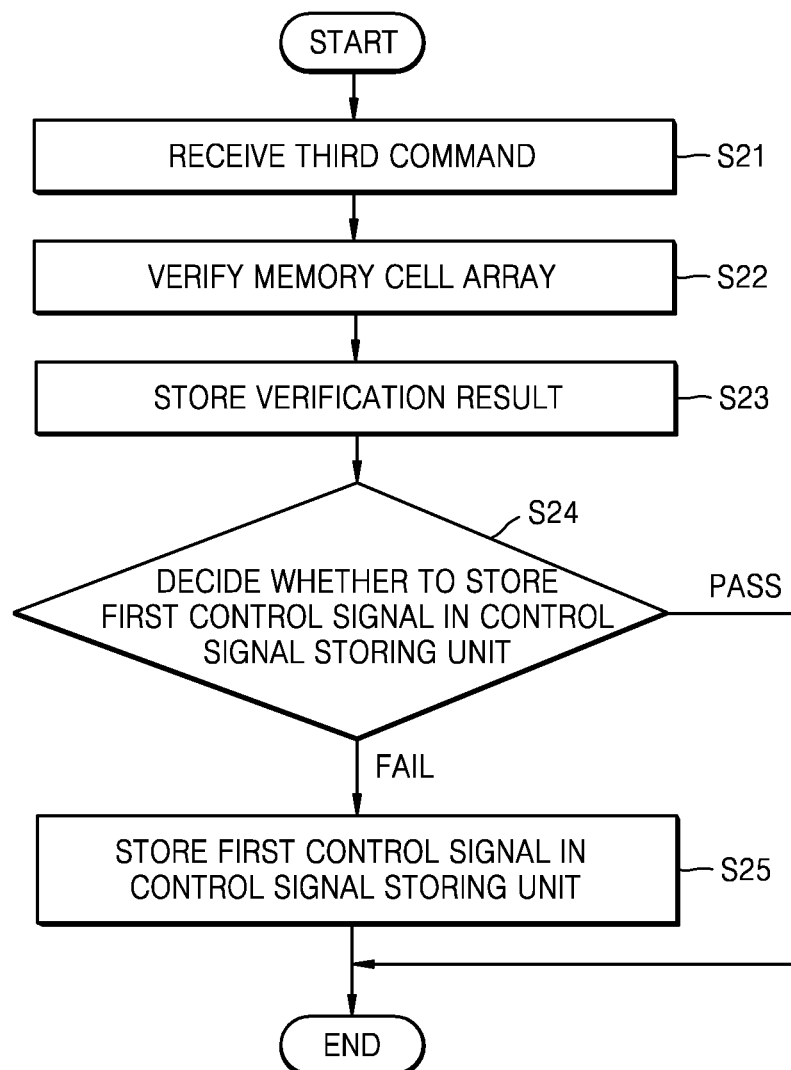


FIG. 11

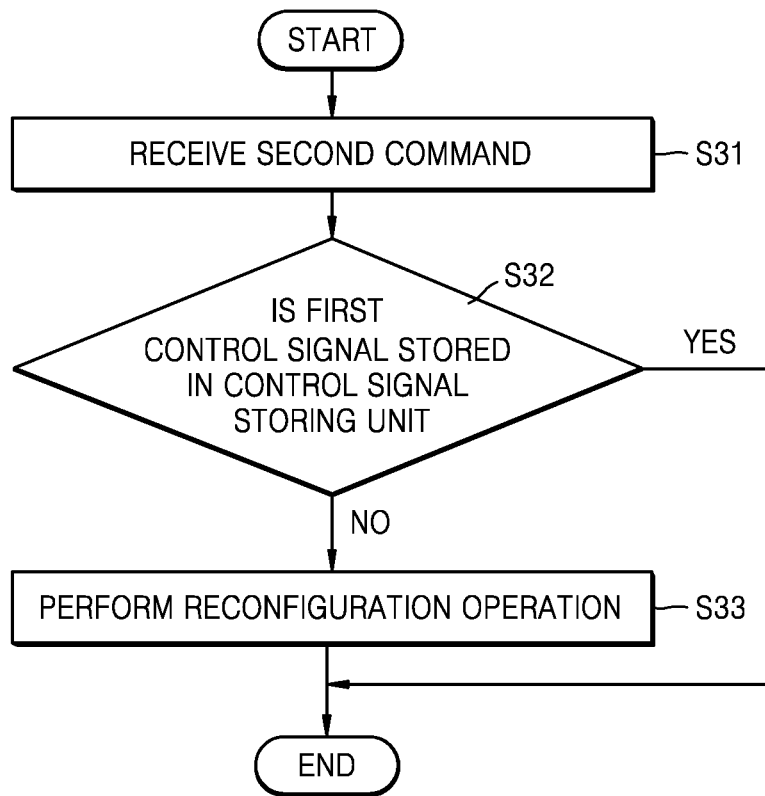


FIG. 12

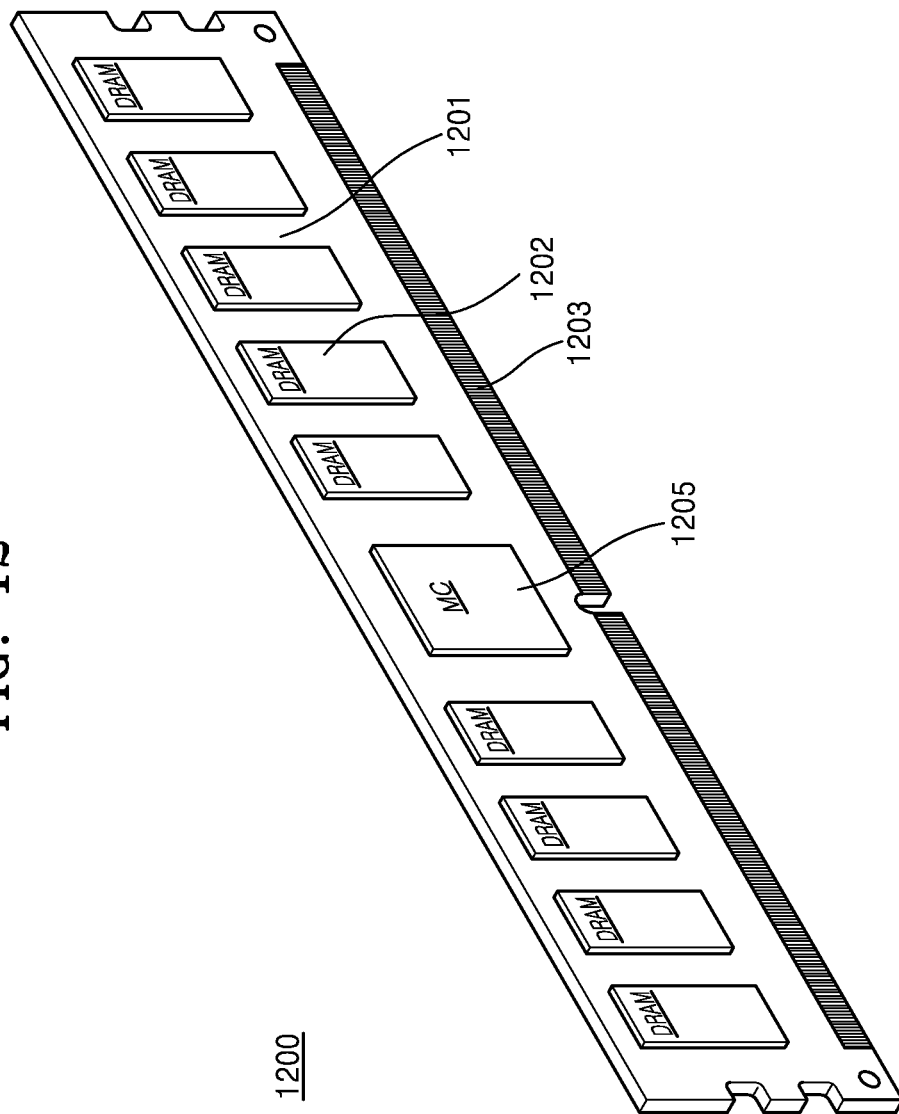


FIG. 13

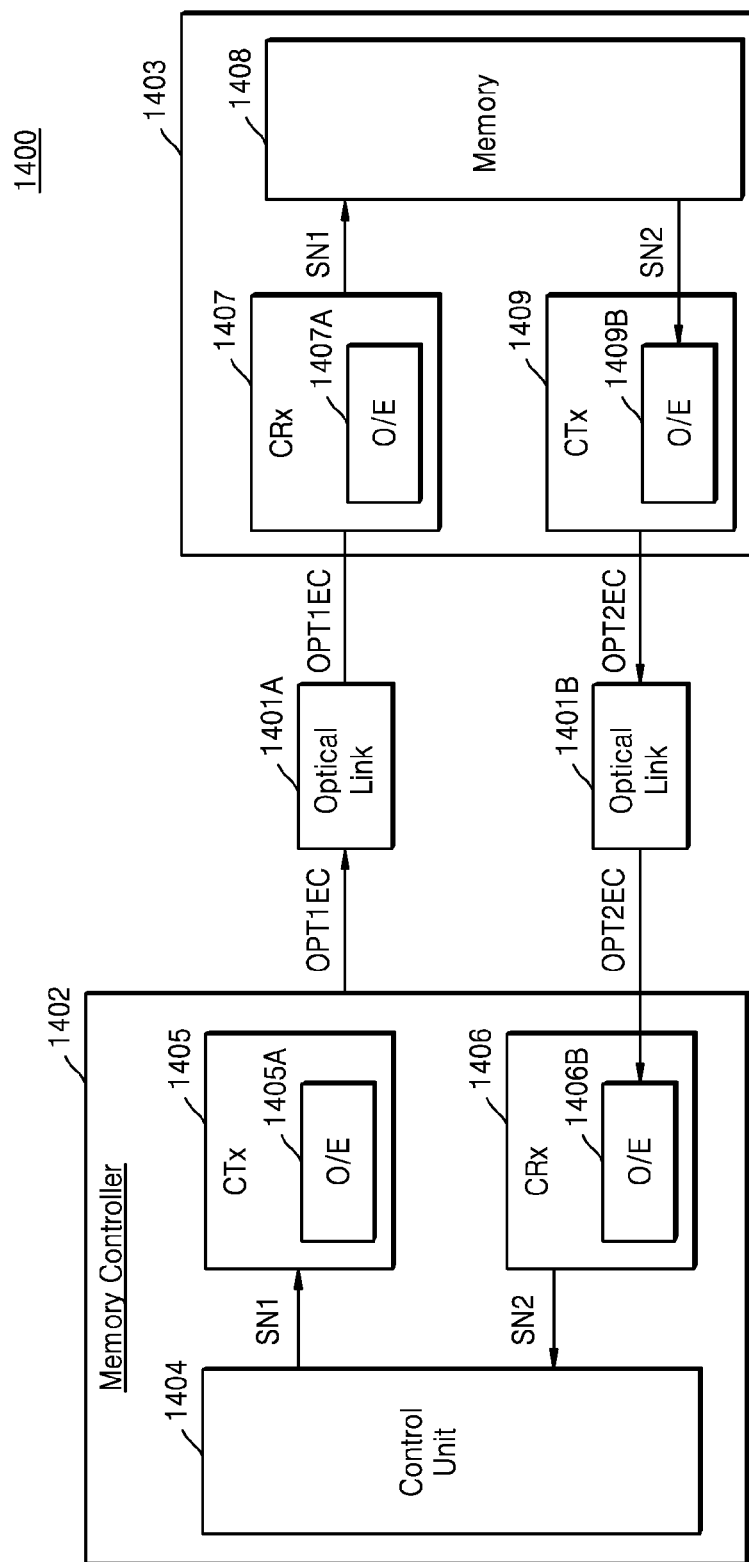
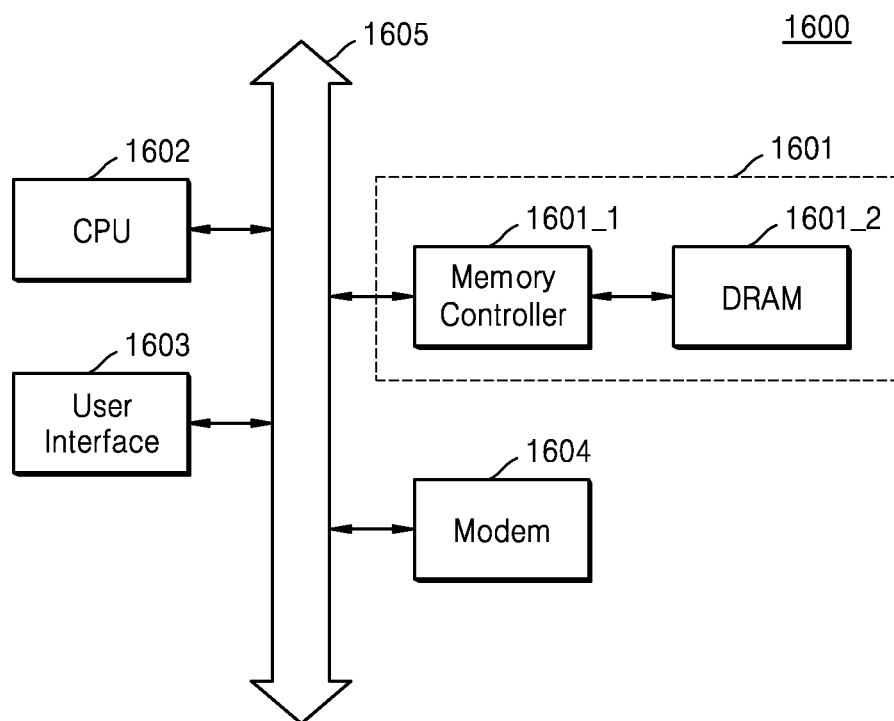


FIG. 14



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SEMICONDUCTOR MEMORY DEVICE AND MEMORY MODULE HAVING RECONFIGURATION REJECTING FUNCTION

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Korean Patent Application No. 10-2014-0107756, filed on Aug. 19, 2014, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

The inventive concept relates to a semiconductor memory device, and more particularly, to a semiconductor memory device and a memory module having a reconfiguration prevention function.

With the development of semiconductor manufacturing technologies, the size of data capable of being stored in a semiconductor memory device has significantly increased. In addition, as sizes of transistors or lines included in a semiconductor memory device have been gradually reduced, it is highly likely that defects will occur during a semiconductor manufacturing process. For example, if shorted or opened word lines and defective transistors occur in a memory cell array of a semiconductor memory device, it may become difficult to normally write, read, or retain data.

A semiconductor memory device may include an element that repairs defects occurring during a semiconductor manufacturing process. For example, a semiconductor memory device may include an element that replaces a region having a defect with another element in a memory cell array. In addition, a semiconductor memory device may include an element that compensates for an individual characteristic of a semiconductor memory device, which may be caused by a deviation in a semiconductor manufacturing process. Such repairing elements may be operated based on information acquired during an operation of testing a semiconductor memory device.

SUMMARY

The inventive concept provides a reconfigurable semiconductor memory device and a memory module including the same, and provides a semiconductor memory device and a memory module that are capable of selectively setting an execution of a reconfiguration operation.

According to an aspect of the inventive concept, there is provided a semiconductor memory device including: a memory cell array that includes a plurality of memory cells; a test information storing unit configured to store test information in a non-volatile manner, based on test results of the plurality of memory cells; and a control unit that includes a control signal storing unit and is configured to prevent programming of the test information storing unit based on a control signal stored in the control signal storing unit.

The control unit may generate a first control signal upon reception of a first command, store the first control signal in the control signal storing unit, and prevent the programming of the test information storing unit according to the stored first control signal upon reception of a second command.

The control signal storing unit may include a one time programmable (OTP) device, and the stored first control signal may correspond to a state in which the OTP device is programmed.

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The control unit may further include: a verification unit configured to verify data stored in the memory cell array upon reception of a third command; a verification result storing unit configured to store a verification result of the verification unit; and a decision unit configured to decide whether to store the first control signal in the control signal storing unit based on one or more verification results stored in the verification result storing unit.

The decision unit may store the first control signal in the control signal storing unit when the number of results corresponding to a failure among the one or more verification results is larger than a reference value.

The verification result storing unit may include a fail address memory configured to store an address corresponding to a defect contained in the memory cell array.

The control unit may receive a command instructing an entry into a test mode and is configured to recognize the first and second commands in the test mode.

The test information storing unit may include an anti-fuse circuit.

The test information storing unit may store information for replacing a defect contained in the memory cell array.

The test information storing unit may store operation characteristic information of the semiconductor memory device, and the operation characteristic information may include timing information and/or voltage level information.

According to another aspect of the inventive concept, there is provided a memory module including: at least one semiconductor memory device; and a memory controller that includes a control signal storing unit and a test information storing unit configured to store test information in a non-volatile manner, based on a test result of the at least one semiconductor memory device, wherein the memory controller is configured to prevent programming of the test information storing unit based on a control signal stored in the control signal storing unit.

The memory controller may store a first control signal upon reception of a first command, store the first control signal in the control signal storing unit, and prevent programming of the test information storing unit according to the stored first control signal upon reception of a second command.

The control signal storing unit may include an OTP device, and the stored first control signal may correspond to a state in which the control signal storing unit is programmed.

The memory controller may further include: a verification unit configured to verify data stored in the semiconductor memory device upon reception of a third command; a verification result storing unit configured to store a verification result of the verification unit; and a decision unit configured to decide whether to store the first control signal in the control signal storing unit based on one or more verification results stored in the verification result storing unit.

The verification result storing unit may include a fail address memory configured to store an address corresponding to a defect contained in the semiconductor memory device.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the inventive concept will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a block diagram of a semiconductor memory device according to an exemplary embodiment of the inventive concept;

FIG. 2 is an exemplary configuration diagram of an anti-fuse circuit included in a test information storing unit of FIG. 1;

FIG. 3 is a diagram of an exemplary operation of testing a plurality of devices;

FIG. 4 is a block diagram illustrating an implementation example of the control unit included in the semiconductor memory device of FIG. 1, according to an exemplary embodiment of the inventive concept;

FIG. 5 is a block diagram illustrating an implementation example of the control unit included in the semiconductor memory device of FIG. 1, according to an exemplary embodiment of the inventive concept;

FIG. 6 is a block diagram of a memory module according to an exemplary embodiment of the inventive concept;

FIG. 7 is a block diagram illustrating an implementation example of the memory controller included in the memory module of FIG. 6, according to an exemplary embodiment of the inventive concept;

FIG. 8 is a block diagram illustrating an implementation example of the memory controller included in the memory module of FIG. 6, according to an exemplary embodiment of the inventive concept;

FIGS. 9 and 10 are flowcharts of methods of controlling a control signal storing unit, according to exemplary embodiments of the inventive concept;

FIG. 11 is a flowchart of a method of performing a reconfiguration operation, according to an exemplary embodiment of the inventive concept;

FIG. 12 is a perspective view of a semiconductor memory device according to an exemplary embodiment of the inventive concept or a memory module according to an exemplary embodiment of the inventive concept;

FIG. 13 is a block diagram of a memory device or a memory system including a memory controller, according to an exemplary embodiment of the inventive concept; and

FIG. 14 is a block diagram of a computer system including a memory controller or a dynamic random-access memory (DRAM), according to an exemplary embodiment of the inventive concept.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Hereinafter, embodiments of the inventive concept will be described with reference to the accompanying drawings. The inventive concept may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the inventive concept to those of ordinary skill in the art. It should be understood, however, that there is no intent to limit the inventive concept to the particular forms disclosed, but on the contrary, the inventive concept is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the inventive concept. Like reference numerals denote like elements throughout the specification and drawings. In the drawings, the dimensions of structures are exaggerated for clarity of the inventive concept. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

The terms used in the present specification are merely used to describe particular embodiments, and are not intended to limit the inventive concept. As used herein, the singular forms “a”, “an”, and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be

understood that the terms such as “comprise”, “include”, and “have”, when used herein, specify the presence of stated features, integers, steps, operations, elements, components, or combinations thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, or combinations thereof.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the inventive concept belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

FIG. 1 is a block diagram of a semiconductor memory device 100 according to an exemplary embodiment of the inventive concept. The semiconductor memory device 100 may receive a command, an address, and data from another device (for example, a memory controller) provided outside the semiconductor memory device 100 and may transmit stored data to an external device in response to the received command. As illustrated in FIG. 1, the semiconductor memory device 100 may include a control unit 110, a memory cell array 120, and a test information storing unit 130. The semiconductor memory device 100 including the three elements is illustrated in FIG. 1, but this is only for illustrative purposes. For example, the semiconductor memory device 100 may further include power circuits, buffers that temporarily store an address and data received from the outside of the semiconductor memory device 100, and the like.

The control unit 110 may receive a command CMD from the outside of the semiconductor memory device 100 and control the elements of the semiconductor memory device 100, for example, the memory cell array 120 and the test information storing unit 130, in response to the received command CMD. According to an exemplary embodiment of the inventive concept, the control unit 110 may include a control signal storing unit 111. The control signal storing unit 111 may store a control signal in response to an electrical signal received by the control unit 110, for example, the command CMD, or may store a control signal based on a process applied to the semiconductor memory device 100, for example, an application of a laser beam. The control unit 110 may control the elements of the semiconductor memory device 100, for example, the test information storing unit 130, in response to the control signal stored in the control signal storing unit 111.

The memory cell array 120 may include a plurality of memory cells. The memory cell array 120 may store data received from the outside of the semiconductor memory device 100 or data generated by encoding the received data, and each of the memory cells may store at least one bit included in the data. The plurality of memory cells, which are included in the memory cell array 120, may be arranged in a matrix form and may be accessed through a plurality of word lines and a plurality of bit lines disposed in the memory cell array 120. The memory cell array 120 may include volatile memory cells, such as static random access memory (SRAM) cells or dynamic random access memory (DRAM) cells. In addition, the memory cell array 120 may include non-volatile memory cells, such as flash memory cells, magnetic random access memory (MRAM) cells, resistance RAM (RRAM) cells, ferroelectric RAM (FRAM) cells, or phase change memory (PCM) cells.

Only the memory cell array 120 is illustrated in FIG. 1 for conciseness, but the semiconductor memory device 100 may

further include a row decoder and a column decoder so as to access the plurality of memory cells included in the memory cell array **120**, and may further include a buffer that temporarily stores data to be written to the memory cell array **120** or temporarily stores data read from the memory cell array **120**.

The test information storing unit **130** may store test information based on the test result of the semiconductor memory device **100**. For example, the test information storing unit **130** may store information for replacing a defect contained in the memory cell array **120**. The test information storing unit **130** may store information for replacing a region including the defect contained in the memory cell array **120** with another region of the memory cell array **120**. The test information storing unit **130** may store address information of the region including the defect or address information of the replacing region.

According to an exemplary embodiment of the inventive concept, the test information storing unit **130** may store information associated with operation characteristics of the semiconductor memory device **100**. The semiconductor memory device **100** may have distinct characteristics due to deviations in a manufacturing process or other factors. For example, an access time to the memory cell included in the memory cell array **120** is several ps and may vary according to the semiconductor memory device **100**. In addition, a power supply voltage for driving the semiconductor memory device **100** is several mV and may vary according to the semiconductor memory device **100**. Timing information and voltage level information may be obtained by testing the semiconductor memory device **100**.

To obtain separate characteristic of the semiconductor memory device **100**, the process of manufacturing the semiconductor memory device **100** may include testing the semiconductor memory device **100**. Referring to FIG. 3, in a test operation, the semiconductor memory device **100** may be connected to a test system **2000**, and the test system **2000** may test the semiconductor memory device **100** by transmitting a signal to the semiconductor memory device **100** or receiving a signal from the semiconductor memory device **100**. In addition, the test system **2000** may transmit a command to the semiconductor memory device **100** so as to store test information in the test information storing unit **130**, based on the test result of the semiconductor memory device **100**. An operation of setting a device based on separate characteristic of a device (for example, the semiconductor memory device **100**), which occurs during the manufacturing process, may be referred to as a reconfiguration operation or a reconfiguration-on-system (ROS). In particular, as one of reconfiguration operations, an operation of writing test information to a specific storage space (for example, the test information storing unit **130**) included in a packaged semiconductor device (for example, the semiconductor memory device **100**) or an operation of programming the storage space may be referred to as a post-package-repair (PPR).

The semiconductor memory device **100** may be controlled to operate in an adjusted or optimized condition based on the timing information and the voltage level information stored in the test information storing unit **130**. For example, the semiconductor memory device **100** may generate a specific voltage from an external power supply voltage based on the voltage level information and supply the generated voltage to the elements of the semiconductor memory device **100**. Due to the test information storing unit **130**, it is less likely to classify the semiconductor memory device **100** as a defective device and it is possible to extend the lifetime of the semiconductor memory device **100**.

According to an exemplary embodiment of the inventive concept, the test information storing unit **130** may include non-volatile memory cells. For example, the test information storing unit **130** may include rewritable non-volatile memory cells, such as flash memory cells, MRAM cells, RRAM cells, FRAM cells, or PCM cells, or may include one time programmable (OTP) type non-volatile memory cells, such as anti-fuse circuits. The non-volatile memory cells, which are included in the test information storing unit **130**, retain information on the test information of the semiconductor memory device **100** even when power supplied to the semiconductor memory device **100** is cut off. Therefore, it is possible to ensure a normal operation of the semiconductor memory device **100**. Due to a laser beam or an electrical signal, two nodes of the anti-fuse circuit may be electrically shorted (or, a state in which the anti-fuse circuit has a very low resistance) or may be electrically opened (or, a state in which the anti-fuse circuit has a very high resistance). In the following, the test information storing unit **130** is described as including the anti-fuse circuit, but it will be understood that the inventive concept is not limited thereto.

According to an exemplary embodiment of the inventive concept, the control unit **110** may control an operation of writing the test information in the test information storing unit **130**, that is, an operation of programming the test information storing unit **130**, in response to a received command CMD. In addition, the control unit **110** may selectively perform the operation of programming the test information storing unit **130** in response to the control signal stored in the control signal storing unit **111**. That is, the control unit **110** may prevent the programming of the test information storing unit **130** according to whether the control signal is stored in the control signal storing unit **111**. In this manner, the semiconductor memory device **100** may prevent the test information storing unit **130** from being programmed with arbitrary data due to an unintended external input signal, for example, a power noise. The control signal storing unit **111** may include volatile memory cells, such as SRAM cells or DRAM cells, or may include non-volatile memory cells, such as flash memory cells, MRAM cells, RRAM cells, FRAM cells, or PCM cells. In addition, the control signal storing unit **111** may include OTP type memory cells, such as anti-fuses.

FIG. 2 is an exemplary configuration diagram of an anti-fuse circuit **10** included in the test information storing unit **130** of FIG. 1. The anti-fuse circuit **10** may include a depletion type MOS transistor, of which a source **12** and a drain **13** are connected to each other. In an initial state, a resistance between a first node **14** connected to a gate electrode **11** and a second node **15** commonly connected to the source **12** and the drain **13** may be very high because the first node **14** and the second node **15** are separated from each other by a gate oxide film. Therefore, a state between the first node **14** and the second node **15** may be an open state (or a very high resistance state).

The gate oxide film may be broken by applying a breakdown voltage between the first node **14** and the second node **15** of the anti-fuse circuit **10**. Therefore, a state between the first node **14** and the second node **15** may irreversibly change from an open state to a closed state (or a very low resistance state). That is, when the gate oxide film is broken, a resistance between the first node **14** and the second node **15** may be reduced. According to an exemplary embodiment of the inventive concept, the test information storing unit **130** may include the anti-fuse circuit **10** as illustrated in FIG. 2, and the control signal storing unit **111** included in the control unit **110** also may include the anti-fuse circuit **10** so as to store the control signal.

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FIG. 3 is a diagram of an exemplary operation of testing a plurality of devices **1001** to **1008**. As illustrated in FIG. 3, the devices **1001** to **1008**, which are being tested, may be referred to as devices under test (DUTs). According to an exemplary embodiment of the inventive concept, the DUTs **1001** to **1008** of FIG. 3 may be the semiconductor memory device of FIG. 1 or a memory module **200** of FIG. 6.

As illustrated in FIG. 3, the DUTs **1001** to **1008** may be electrically connected to the test system **2000**. To reduce the time required for the test operation, the DUTs **1001** to **1008** may share one or more signal lines (for example, buses) connected to the test system **2000**. Therefore, the DUTs **1001** to **1008** may be simultaneously tested by the test system **2000**. That is, the DUTs **1001** to **1008** may simultaneously receive the same command from the test system **2000** and simultaneously perform the operations according to the received command. In addition, the DUTs **1001** to **1008** may share a power line through which the power is supplied from the test system **2000**. The eight DUTs **1001** to **1008** are illustrated in FIG. 3, but this is only for illustrative purposes. Less than eight DUTs or more than eight DUTs may be connected to the test system **2000**.

The test system **2000** may transmit the command for the reconfiguration operation to the DUTs **1001** to **1008**, and the DUTs **1001** to **1008** may perform the reconfiguration operation according to the command received from the test system **2000**. For example, the semiconductor memory device **100** of FIG. 1 may receive the command CMD from the test system **2000** and program the test information storing unit **130** in response to the received command CMD.

For some of the DUTs **1001** to **1008**, the reconfiguration operation needs to be prevented. For example, the DUT **1001** may be mounted on a socket so as to electrically connect to the test system **2000**, and a contact failure may occur between the socket and the DUT **1001**. In addition, the DUT **1002** may contain a non-repairable defect, and the DUT **1003** may be in a state of being falsely tested due to an unexpected signal noise. In a case where the DUTs **1001**, **1002**, and **1003** perform the reconfiguration operation according to the command received from the test system **2000**, the DUTs **1001**, **1002**, and **1003** may be set to an inappropriate condition. Hence, in a subsequent operation, repairing the DUTs **1001**, **1002**, and **1003** to normal DUTs or using as documents for DUT analysis may be prevented.

Although DUTs, of which the reconfiguration operation is required to be prevented, exist among the DUTs **1001** to **1008** connected to the test system **2000**, it may be difficult for the test system **2000** to individually control the DUTs **1001** to **1008** because the DUTs **1001** to **1008** share the power line and the signal line with one another. Therefore, there is a need to individually control the reconfiguration operation with respect to the DUTs **1001** to **1008**.

FIG. 4 is a block diagram illustrating an implementation example **110a** of the control unit **110** included in the semiconductor memory device **100** of FIG. 1, according to an exemplary embodiment of the inventive concept. According to an exemplary embodiment of the inventive concept, the control unit **110a** of FIG. 4 may receive a command CMD from a device (for example, a memory controller) disposed outside the semiconductor memory device **100** and program a test information storing unit **130a** in response to the received command CMD. As illustrated in FIG. 4, the control unit **110a** may include a control signal storing unit **111a**, a command decoder **112a**, a logic unit **113a**, and a ROS controller **114a**.

The command decoder **112a** may decode the received command CMD and generate a control signal in response to

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the received command CMD. For example, the command decoder **112a** may receive a first command and generate a first control signal C1 based on the received first command. In addition, the command decoder **112a** may receive a second command and generate a second control signal C2 based on the received second command. According to an exemplary embodiment of the inventive concept, the control unit **110a** may store the first control signal C1, which is output by the command decoder **112a** upon reception of the first command, in the control signal storing unit **111a**. That is, the stored first control signal C1 may indicate that the control signal storing unit **111a** is in a programmed state. For example, the control signal storing unit **111a** may include the anti-fuse circuit **10** illustrated in FIG. 2, and the control unit **110a** may program the anti-fuse circuit **10** according to the first control signal C1 generated by the command decoder **112a**, that is, change the gap between the first node **14** and the second node **15** of the anti-fuse circuit **10** to a closed state.

According to an exemplary embodiment of the inventive concept, the second command, which is received by the control unit **110a** (that is, the command decoder **112a**), may instruct the semiconductor memory device **100** to perform the reconfiguration operation. The second control signal C2, which is generated by the command decoder **112a** in response to the second command, may be used to control the ROS controller **114a**. In addition, according to an exemplary embodiment of the inventive concept, the control unit **110a** may receive a command instructing an entry into a test mode and enter the test mode accordingly. The command decoder **112a** of the control unit **110a** may recognize, that is, decode the first and second commands in a state in which the control unit **110a** enters the test mode.

The logic unit **113a** may be connected to the control signal storing unit **111a** and receive the second control signal C2 from the command decoder **112a**. The control signal storing unit **111a** may transmit, to the logic unit **113a**, a signal indicating whether the first control signal is stored, and the logic unit **113a** may generate an enable signal EN based on the received signals. In a case where the control signal storing unit **111a** stores the first control signal, the logic unit **113a** may deactivate the enable signal EN so as to prevent the second control signal C2 from being transmitted to the ROS controller **114a**.

The ROS controller **114a** may control the reconfiguration operation of the semiconductor memory device **100**. For example, the ROS controller **114a** may perform control such that the test information is stored in the test information storing unit **130a**. As illustrated in FIG. 4, the ROS controller **114a** may receive the enable signal EN from the logic unit **113a** and control the start of the reconfiguration operation when the enable signal EN is activated.

According to an exemplary embodiment of the inventive concept, the control unit **110a** may selectively prevent the execution of the reconfiguration operation of the semiconductor memory device **100** by providing the control signal storing unit **111a** and supporting the first command for programming the control signal storing unit **111a**. For example, in a case where the control signal storing unit **111a** includes the anti-fuse circuit **10** illustrated in FIG. 2, the semiconductor memory device **100** receives the control signal in a final step of the process of manufacturing the semiconductor memory device **100**. Therefore, it is possible to prevent the semiconductor memory device **100** from performing the reconfiguration operation due to an unexpected cause while the semiconductor memory device is operated by a user.

FIG. 5 is a block diagram illustrating an implementation example **110b** of the control unit **110** included in the semi-

conductor memory device **100** of FIG. **1**, according to an exemplary embodiment of the inventive concept. As in the implementation example **110a** of FIG. **4**, the control unit **110b** of FIG. **5** may receive a command CMD from a memory controller or the like and program a test information storing unit **130b** in response to the received command CMD. As illustrated in FIG. **5**, the control unit **110b** may include a control signal storing unit **111b**, a command decoder **112b**, a logic unit **113b**, a ROS controller **114b**, a verification unit **115b**, a verification result storing unit **116b**, and a decision unit **117b**. According to an exemplary embodiment of the inventive concept, the control unit **110b** of FIG. **5** may store a control signal in the control signal storing unit **111b** in a different method from the control unit **110a** of FIG. **4**. Since the functions of the logic unit **113b** and the ROS controller **114b** are similar to those of the exemplary embodiment of FIG. **4**, a description of the logic unit **113b** and the ROS controller **114b** will be omitted.

The command decoder **112b** may receive a second command and then generate a second control signal C2 based on the received second command. In addition, the command decoder **112b** may receive a third command and generate a third control signal C3 based on the received third command. As in the exemplary embodiment of FIG. **4**, the second command may instruct the semiconductor memory device **100** to perform the reconfiguration operation, and the second control signal C2, which is generated by the command decoder **112b** in response to the second command, may be used to control the ROS controller **114b**. According to an exemplary embodiment of the inventive concept, the third command, which is received by the control unit **110b** (that is, the command decoder **112b**), may instruct the semiconductor memory device **100** to perform a verification operation. The third control signal C3, which is generated by the command decoder **112b** in response to the second command, may be transmitted to the verification unit **115b**.

In addition, according to an exemplary embodiment of the inventive concept, the control unit **110b** may receive a command instructing an entry into a test mode and enter the test mode accordingly. The command decoder **112b** of the control unit **110b** may recognize, that is, decode the first, second, and third commands in a state in which the control unit **110b** enters the test mode.

The verification unit **115b** may perform the operation of verifying the memory cell array **120b**. For example, the verification unit **115b** may include at least one comparator, and the comparator may compare data received from the outside of the semiconductor memory device **100** with data read from the memory cell array **120b**. A test system for testing the semiconductor memory device **100**, such as the test system **2000** of FIG. **2**, may transmit a command instructing the writing of the first data to the semiconductor memory device **100** and transmits the third command. Then, the test system for testing the semiconductor memory device **100** may provide the first data to the semiconductor memory device **100**, and the comparator included in the verification unit **115b** may compare the data read from the memory cell array **120b** with the first data provided from the test system. When the data read from the memory cell array **120b** is identical to the first data, the verification unit **115b** may determine that the verification of the memory cell array **120b** is passed. On the other hand, when the data read from the memory cell array **120b** is different from the first data, the verification unit **115b** may determine that the verification of the memory cell array **120b** failed and generate a signal corresponding to the determination result. At this time, the verification unit **115b** may addi-

tionally generate information on a region of the memory cell array, of which the verification failed, that is, an address signal.

According to an exemplary embodiment of the inventive concept, the semiconductor memory device **100** may store a control signal in the control signal storing unit **111b**, based on the verification result of the verification unit **115b**. The third command may instruct a relatively simple verification operation, and the verification unit **115b** may perform the verification operation in response to the third command (that is, the third control signal C3 generated by the third command). Therefore, by selectively storing the control signal in the control signal storing unit **111b** based on the verification result, the semiconductor memory device **100** may perform the reconfiguration operation in response to the second command only when passing the simple verification. Like the DUTs **1001**, **1002**, and **1003** of FIG. **2**, the semiconductor memory device **100**, of which the reconfiguration operation needs to be prevented due to a contact failure or the like, may be determined when the verification performed by the verification unit **115b** in response to the third command failed. The subsequent reconfiguration operation in response to the second command may be prevented in the semiconductor memory device **100**, such as the DUTs **1001**, **1002**, and **1003** of FIG. **2**. According to an exemplary embodiment of the inventive concept, in a case where the control signal storing unit **111b** includes non-volatile memory cells, the semiconductor memory device **100**, of which the reconfiguration operation has been prevented, may be tested again after the problem such as the contact failure is solved.

The verification result storing unit **116b** may store the signal that is generated according to the verification result by the verification unit **115b**. For example, when the verification unit **115b** determines that the verification failed and generates a signal corresponding to the determination result, the verification result storing unit **116b** may store the generated signal. The verification unit **115b** may perform the verification operation twice or more, and the verification result storing unit **116b** may store signals corresponding to a plurality of determination results of the verification unit **115b**.

The decision unit **117b** may decide whether to store the control signal in the control signal storing unit **111b**, that is, whether to program the control signal storing unit **111b**, based on one or more verification results stored in the verification result storing unit **116b**. For example, the verification unit **115b** may perform the verification operation a preset number of times in response to the third control signal C3, and the verification result storing unit **116b** may store the verification results that the verification unit **115b** determines as failed. In a case where the number of the verification results, which are determined as failed and are stored in the verification result storing unit **116b**, is larger than a reference value, the decision unit **117b** may program the control signal storing unit **111b**. Alternatively, the plurality of verifications performed by the verification unit **115b** may be different types, and the decision unit **117b** may decide whether to program the control signal storing unit **111b** based on the verification results of the different types of the verifications. For example, the verification unit **115b** may perform first, second, and third verifications, and the decision unit **117b** may program the control signal storing unit **111b** when the first verification failed or when both the second and third verifications failed.

According to an exemplary example of the inventive concept, the verification unit **115b** may be used in the reconfiguration operation. That is, the verification unit **115b** may be used to determine a defect contained in the memory cell array **120b**. When the defect is detected, the verification unit **115b**

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may generate an address signal for a region containing the defect. The ROS controller **114b** may program the test information storing unit **130b** based on the address signal generated by the verification unit **115b**. Therefore, the region containing the defect may be replaced with another region of the memory cell array **120b**. The address signal generated by the verification unit **115b** may be stored in a fail address memory (FAM) as a temporary storage space, and the ROS controller **114b** may access the FAM. According to an exemplary example of the inventive concept, the verification result storing unit **116b** may be a FAM. That is, the control unit **110b** may use the FAM as the verification result storing unit **116b** that is used for determining whether to store the control signal in the control signal storing unit **111b**.

According to an exemplary embodiment of the inventive concept, the single semiconductor memory device **100** illustrated in FIG. 1 may include the implementation examples **110a** and **110b** of the control unit **110** illustrated in FIGS. 4 and 5. That is, the control unit **110** illustrated in FIG. 1 may receive the first, second, and third commands and generate the first, second, and third control signals **C1**, **C2**, and **C3** in response to the first, second, and third commands. The control unit **110** may store the control signals in the control signal storing unit **111** in response to the first command, or may verify the memory cell array **120b** in response to the third command and store the control signals in the control signal storing unit **111** based on the verification result. The control unit **110** may prevent the reconfiguration operation in response to the reception of the second command according to whether the control signal is stored in the control signal storing unit **111**.

FIG. 6 is a block diagram of a memory module **200** according to an exemplary embodiment of the inventive concept. The memory module **200** may be used as a main memory of a computing system and may include at least one semiconductor memory device. In FIG. 6, the memory module **200** is illustrated as including a DRAM device **220**, but the memory module **200** according to the inventive concept is not limited thereto. As illustrated in FIG. 6, the memory module **200** may include a memory controller **210** and a DRAM device **220**. The memory controller **210** may receive a command **CMD_M** from an external device (for example, a main memory controller) of the memory module **200** and control the memory module **200** in response to the received command **CMD_M**. Although not illustrated, the memory controller **210** may receive an address and data from the external device of the memory module **200** and transmit data stored in the DRAM device **220** to the external device.

According to an exemplary embodiment of the inventive concept, the memory controller **210** may include a control signal storing unit **211** and a test information storing unit **219**. The control signal storing unit **211** and the test information storing unit **219** may operate similarly to the control signal storing unit **111** and the test information storing unit **130** included in the semiconductor memory device **100** of FIG. 1.

The test information storing unit **219** may store test information based on the test result of the memory module **200**. As in the semiconductor memory device **100**, the process of manufacturing the memory module **200** may include testing the memory module **200** so as to obtain separate characteristics of the memory module **200**. Referring to FIG. 3, the memory module **200** may be connected to a test system **2000**, and the test system **2000** may test the memory module **200** by transmitting a signal to the memory module **200** or receiving a signal from the memory module **200**. The test system **2000** may transmit a command to the memory module **200** so as to store test information in the test information storing unit **219**,

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based on the test result of the memory module **200**. The memory module **200** may be controlled to operate in an adjusted or optimized condition based on the test information stored in the test information storing unit **219**.

According to an exemplary embodiment of the inventive concept, the test information storing unit **219** may include non-volatile memory cells. For example, the test information storing unit **219** may include rewritable non-volatile memory cells, such as flash memory cells, MRAM cells, RRAM cells, FRAM cells, or PCM cells, or may include OTP type non-volatile memory cells, such as anti-fuse circuits. In the following, the test information storing unit **219** is described as including the anti-fuse circuit, but it will be understood that the inventive concept is not limited thereto.

According to an exemplary embodiment of the inventive concept, the memory controller **210** may selectively perform the operation of programming the test information storing unit **219** in response to the control signal stored in the control signal storing unit **211**. That is, the memory controller **210** may prevent the programming of the test information storing unit **219** according to whether the control signal is stored in the control signal storing unit **211**. In this manner, the memory module **200** may prevent the programming of the test information storing unit **219** with arbitrary data due to an unintended external input signal, for example, a power noise. The control signal storing unit **211** may include volatile memory cells, such as SRAM cells or DRAM cells, or may include non-volatile memory cells, such as flash memory cells, MRAM cells, RRAM cells, FRAM cells, or PCM cells. In addition, the control signal storing unit **211** may include OTP type memory cells, such as anti-fuses.

FIG. 7 is a block diagram illustrating an implementation example **210a** of the memory controller **210** included in the memory module **200** of FIG. 6, according to an exemplary embodiment of the inventive concept. As illustrated in FIG. 7, the memory controller **210a** may include a control signal storing unit **211a**, a command decoder **212a**, a logic unit **213a**, and a ROS controller **214a**. When compared with the control unit **110a** and the test information storing unit **130a** included in the semiconductor memory device **100** of FIG. 4, the respective elements of FIG. 7 may perform similar operations to the respective elements of FIG. 4. On the other hand, the test information storing unit **219a** may store test information based on the test result of the DRAM device **220** of FIG. 6.

The command **CMD_M**, which is received by the command decoder **212a** of the memory controller **210a**, may include a first command or a second command. The first and second commands may instruct the memory module **200** to perform similar operations to those instructed by the first and second commands received by the control unit **110a** of FIG. 4. The command decoder **212a** may generate a first control signal **C1_M** and a second control signal **C2_M**, respectively, in response to the received first and second commands. The logic unit **213a** may generate an enable signal **EN_M** according to the signal received from the control signal storing unit **211a** and the second control signal **C2_M** and transmit the generated enable signal **EN_M** to the ROS controller **214a**. The ROS controller **214a** may control the start of the reconfiguration operation in response to the enable signal **EN_M**. The operations of the other elements of the memory controller **210a** may be similar to those of the corresponding elements of the control unit **110a** of FIG. 4.

In addition, according to an exemplary embodiment of the inventive concept, the memory controller **210a** may receive a command instructing an entry into a test mode and enter the test mode accordingly. The command decoder **212a** of the

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memory controller **210a** may recognize, that is, decode the first and second commands in a state in which the memory controller **210a** enters the test mode.

FIG. **8** is a block diagram illustrating an implementation example **210b** of the memory controller **210** included in the memory module **200** of FIG. **6**, according to an exemplary embodiment of the inventive concept. As in the implementation example **210a** of FIG. **5**, the memory controller **210b** of FIG. **8** may receive a command CMD_M from an external device of the memory module. As illustrated in FIG. **8**, the memory controller **210b** may include a control signal storing unit **211b**, a command decoder **212b**, a logic unit **213b**, a ROS controller **214b**, a verification unit **215b**, a verification result storing unit **216b**, a decision unit **217b**, and a test information storing unit **219b**. When compared with the control unit **110b** and the test information storing unit **130b** included in the semiconductor memory device **100** of FIG. **5**, the respective elements of FIG. **8** may perform similar operations to the respective elements of FIG. **5**. On the other hand, the verification unit **215b** may verify the DRAM device **220b** and the test information storing unit **219b** may store test information based on the test result of the DRAM device **220b** of FIG. **216**.

The command CMD_M, which is received by the command decoder **212b** of the memory controller **210b**, may include a second command or a third command. The second and third commands may instruct the memory module **200** to perform similar operations to those instructed by the second and third commands received by the control unit **110b** of FIG. **5**. The command decoder **212b** may generate a second control signal C2_M and a third control signal C3_M, respectively, in response to the received second and third commands. The logic unit **213b** may generate an enable signal EN_M according to the signal received from the control signal storing unit **211b** and the second control signal C2_M and transmit the generated enable signal EN_M to the ROS controller **214b**. The ROS controller **214b** may control the start of the reconfiguration operation in response to the enable signal EN_M.

In addition, according to an exemplary embodiment of the inventive concept, the memory controller **210b** may receive a command instructing an entry into a test mode and enter the test mode accordingly. The command decoder **212b** of the memory controller **210b** may recognize, that is, decode the first, second, and third commands in a state in which the memory controller **210b** enters the test mode.

The verification unit **215b** may generate a third control signal C3_M from the command decoder **212b** and verify the DRAM device **220b** in response to the third control signal C3_M. For example, the verification unit **215b** may transmit a command instructing writing of second data to the DRAM device **220b** and may transmit a command instructing reading of the second data. Then, the verification unit **215b** may compare data read from the DRAM device **220b** with the second data. Then, when the data read from the DRAM device **220b** is identical to the second data, the verification unit **215b** may determine that the verification of the DRAM device **220b** passed. On the other hand, when the data read from the DRAM device **220b** is different from the second data, the verification unit **215b** may determine that the verification of the DRAM device **220b** failed and generate a signal corresponding to the determination result. At this time, the verification unit **215b** may additionally generate information on a region of the DRAM device **220b**, of which the verification failed, that is, an address signal. In addition, when the memory module **200** includes a plurality of DRAM devices, the verification unit **215b** may generate a signal corresponding to identification information of DRAM devices, of which the verification failed, among the plurality of DRAM devices.

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The operations of the other elements of the memory controller **210b** may be similar to those of the corresponding elements of the control unit **110b** of FIG. **5**.

According to an exemplary embodiment of the inventive concept, the single memory module **200** illustrated in FIG. **6** may include the implementation examples **210a** and **210b** of the memory controller **210** as illustrated in FIGS. **7** and **8**. That is, the memory controller **210** of FIG. **6** may receive the first, second, and third commands and generate the first, second, and third control signals C1_M, C2_M, and C3_M in response to the first, second, and third commands. The memory controller **210** may store the control signals in the control signal storing unit **211** in response to the first command, or may verify the DRAM device **220** in response to the third command and store the control signals in the control signal storing unit **211** based on the verification result. The memory controller **210** may prevent the reconfiguration operation in response to the reception of the second command according to whether the control signal is stored in the control signal storing unit **211**.

FIGS. **9** and **10** are flowcharts of methods of controlling a control signal storing unit, according to exemplary embodiments of the inventive concept. In FIGS. **9** and **10**, the control signal storing unit may be one of the control signal storing units **111a** and **111b** included in the control units **110a** and **110b** of the semiconductor memory device **100** illustrated in FIGS. **4** and **5**, or may be one of the control signal storing units **211a** and **211b** included in the memory controllers **210a** and **210b** of the memory module **200** illustrated in FIGS. **7** and **8**. In the following, a method of controlling a control signal storing unit according to an exemplary embodiment of the inventive concept will be described with reference to the control units **110a** and **110b** according to the exemplary embodiments illustrated in FIGS. **1** to **5**, but it will be understood that the inventive concept is not limited thereto.

Referring to FIGS. **4** and **9**, in operation S11, the control unit **110a** may receive a first command. In operation S12, the control unit **110a** may store a control signal in the control signal storing unit **111a** in response to the received first command. For example, according to an exemplary embodiment of the inventive concept, when the control signal storing unit **111a** includes the anti-fuse circuit of FIG. **2**, the control unit **110a** may program the anti-fuse circuit upon reception of the first command. By transmitting the first command to the semiconductor memory device **100**, the test system for testing the semiconductor memory device **100**, such as the test system **2000** of FIG. **2**, is capable of preventing the semiconductor memory device **100** from performing the reconfiguration operation due to an unexpected external input signal. For example, the test system is capable of preventing the test information storing unit **130a** from being programmed with arbitrary data.

Referring to FIGS. **5** and **10**, in operation S21, the control unit **110b** may receive a third command. In operation S22, the verification unit **115b** included in the control unit **110b** may verify the memory cell array **120b** according to a third control signal C3 generated in response to the third command received by the command decoder **112b**. In operation S23, the verification result storing unit **116b** may store verification result of the verification unit **115b**. For example, the verification unit **115b** may verify the memory cell array **120b** twice or more, and the verification result storing unit **116b** may store a plurality of verification results.

In operation S24, the decision unit **117b** may decide whether to store the control signal in the control signal storing unit **111b** based on the verification result stored in the verification result storing unit **116b**. For example, in operation S25,

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the decision unit **117b** may store the control signal in the control signal storing unit **111b**, that is, program the control signal storing unit **111b**, when the number of the verification results, which correspond to the verification failure and are stored in the verification result storing unit **116b**, is larger than a reference value.

FIG. **11** is a flowchart of a method of performing a reconfiguration operation, according to an exemplary embodiment of the inventive concept. In FIG. **11**, the reconfiguration operation may be controlled by one selected from among the ROS controllers **114a**, **114b**, **214a**, and **214b** illustrated in the preceding drawings. In the following, the method of performing the reconfiguration operation according to the exemplary embodiment of the inventive concept will be described with reference to the control unit **110a** illustrated in FIG. **4**, but it will be understood that the inventive concept is not limited thereto.

Referring to FIGS. **4** and **11**, in operation **S31**, the control unit **110a** may receive a second command. In operation **S32**, the control unit **110a** may determine whether the first control signal is stored in the control signal storing unit **111a**. For example, the logic unit **113a** may receive a signal from the control signal storing unit **111a** and receive a second control signal **C2** generated by the command decoder **112a** in response to the second command. In a case where the signal received from the control signal storing unit **111a** stores the first control signal, the logic unit **113a** may deactivate an enable signal **EN** so as to prevent the second control signal **C2** from being transmitted to the ROS controller **114a**. On the other hand, in a case where the signal received from the control signal storing unit **111a** does not store the first control signal, the logic unit **113a** may activate the enable signal **EN** in response to the second control signal. In operation **S33**, the ROS controller **114a** may control the reconfiguration operation so that the control unit **110a** performs the reconfiguration operation.

FIG. **12** is a perspective view of a module including a semiconductor memory device according to an exemplary embodiment of the inventive concept or a memory module according to an exemplary embodiment of the inventive concept. According to an exemplary embodiment of the inventive concept, the memory module **1200** may include a printed circuit board **1201**, a plurality of DRAM chips **1202**, a connector **1203**, and a memory controller **1205**. The memory controller **1205** may control operation modes of the DRAM chips **1202** and may control various functions, characteristics, and modes by using mode registers of the DRAM chips **1202**. Each of the DRAM chips **1202** may support a DDR mode and include a plurality of data input terminals through which data is input or output according to the DDR mode.

The DRAM chip **1202** may be the semiconductor memory device according to the exemplary embodiment of the inventive concept. For example, the DRAM chip **1202** may be the semiconductor memory device **100** including the control unit **110a** or **110b** illustrated in FIG. **4** or **5**. Therefore, the DRAM chip **1202** may include the control signal storing unit and selectively perform the reconfiguration operation according to the control signal stored in the control signal storing unit.

The memory module **1200** may be the memory module according to the exemplary embodiment of the inventive concept. For example, the memory controller **1205**, which is connected to the DRAM chips **1202**, may be the memory controller **210a** or **210b** illustrated in FIG. **7** or **8**. Therefore, the memory controller **1205** may include the control signal storing unit and selectively perform the reconfiguration operation according to the control signal stored in the control signal storing unit.

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The memory module **1200** may be configured in a type selected from among a single in-line memory module (SIMM), a dual in-line memory module (DIMM), a small-outline DIMM (SO_DIMM), an unbuffered DIMM (UDIMM), a fully-buffered DIMM (FBDIMM), a rank-buffered DIMM (RBDIMM), a load-reduced DIMM (LRDIMM), a mini-DIMM, and a micro-DIMM.

FIG. **13** is a block diagram of a memory device or a memory system including a memory controller, according to an exemplary embodiment of the inventive concept. As illustrated in FIG. **13**, the memory system **1400** may include optical link devices **1401A** and **1401B**, a memory controller **1402**, and a DRAM **1403**. The optical link devices **1401A** and **1401B** may connect the memory controller **1402** to the DRAM **1403**. The memory controller **1402** may include a control unit **1404**, a first transmission unit **1405**, and a first reception unit **1406**. The control unit **1404** may transmit a first electrical signal **SN1** to the first transmission unit **1405**. The first electrical signal **SN1** may include command signals, clocking signals, address signals, or write data, which are transmitted to the DRAM **1403**.

The first transmission unit **1405** may include a first optical modulator **1405A**, and the first optical modulator **1405A** may convert the first electrical signal **SN1** into a first optical transmission signal **OPT1EC** and transmit the first optical transmission signal **OPT1EC** to the optical link device **1401A**. The first optical transmission signal **OPT1EC** may be transmitted through the optical link device **1401A** by serial communication. The first reception unit **1406** may include a first optical demodulator **1406B**, and the first optical demodulator **1406B** may convert a second optical reception signal **OPT2EC** received from the optical link device **1401B** into a second electrical signal **SN2** and transmit the second electrical signal **SN2** to the control unit **1404**. The second electrical signal **SN2** may include a data signal **DQ** and a data strobe signal **DQS**. The memory controller **1402** may be one of the memory controllers according to the exemplary embodiments of the inventive concept. For example, the memory controller **1402** may be the memory controller **210a** or **210b** illustrated in FIG. **7** or **8**. Therefore, the memory controller **1402** may include the control signal storing unit and selectively perform the reconfiguration operation according to the control signal stored in the control signal storing unit.

The DRAM **1403** may include a second reception unit **1407**, a memory area **1408** including a memory cell array, and a second transmission unit **1409**. The second reception unit **1407** may include a second optical demodulator **1407A**, and the second optical demodulator **1407A** may convert the first optical reception signal **OPT1EC** received from the optical link device **1401A** into the first electrical signal **SN1** and transmit the first electrical signal **SN1** to the memory area **1408**.

In the memory area **1408**, write data may be written to the memory cell in response to the first electrical signal **SN1**, or data read from the memory area **1408** may be transmitted to the second transmission unit **1409** as the second electrical signal **SN2**. The first electrical signal **SN1** may include a signal corresponding to an input data sequence **DQ** and a data strobe signal **DQS**. The memory area **1408** may include the control unit according to the exemplary embodiment of the inventive concept. For example, the memory area **1408** may include the control unit **110a** or **110b** illustrated in FIG. **4** or **5**. Therefore, the control unit included in the memory area **1408** may include the control signal storing unit and selectively perform the reconfiguration operation according to the control signal stored in the control signal storing unit.

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The second electrical signal SN2 may include a clocking signal and read data, which are transmitted to the memory controller 1402. The second transmission unit 1409 may include a second optical modulator 1409B, and the second optical modulator 1409B may convert the second electrical signal SN2 into the second optical transmission signal OPT2EC and transmit the second optical transmission signal OPT2EC to the optical link device 1401B. The second optical transmission signal OPT2EC may be transmitted through the optical link device 1401B by serial communication.

FIG. 14 is a block diagram of a computer system 1600 including a memory controller 1601_1 or a DRAM 1601_2, according to an exemplary embodiment of the inventive concept. The computer system 1600 may be mounted on a mobile device or a desktop computer. The computer system 1600 may include a DRAM memory system 1601 electrically connected to a system bus 1605, a central processing unit (CPU) 1602, a user interface 1603, and a modem 1604 such as a baseband chipset. The computer system 1600 may further include an application chipset, a camera image processor, and an input/output device.

The user interface 1603 may be an interface that transmits data to a communication network or receives data from the communication network. The user interface 1603 may be a wired/wireless type user interface 1603 or may include an antenna or a wired/wireless transceiver. The user interface 1603 may store data provided through the modem 1604 or data processed by the CPU 1602 in the DRAM memory system 1601.

The DRAM memory system 1601 may include a DRAM 1601_2 and a memory controller 1601_1. The DRAM 1601_2 may store data processed by the CPU 1602 or data input from the outside. The DRAM 1601_2 may be one of the semiconductor memory devices according to the exemplary embodiments of the inventive concept. Therefore, the DRAM 1601_2 may include the control signal storing unit and selectively perform the reconfiguration operation according to the control signal stored in the control signal storing unit.

The memory controller 1601_1 may be one of the memory controllers according to the exemplary embodiments of the inventive concept. In addition, the DRAM memory system 1601 may be one of the memory modules according to the exemplary embodiments of the inventive concept. Therefore, the memory controller 1601_1 may include the control signal storing unit and selectively perform the reconfiguration operation according to the control signal stored in the control signal storing unit.

In a case where the computer system 1600 is a system that performs wireless communication, the computer system 1600 may be used in a communication system, such as Code Division Multiple Access (CDMA), Global System for Mobile Communication (GSM), North American Digital Cellular (NADC), and CDMA2000. The computer system 1600 may be mounted on an information processing device, such as a personal digital assistant (PDA), a portable computer, a web tablet, a digital camera, a portable media player (PMP), a mobile phone, a wireless phone, and a laptop computer.

While the inventive concept has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood that various changes in form and details may be made therein without departing from the spirit and scope of the following claims.

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What is claimed is:

1. A semiconductor memory device comprising:

a memory cell array including a plurality of memory cells; a test information storing unit configured to store test information in a non-volatile manner, wherein the test information is based on test results of the plurality of memory cells; and

a control unit including a control signal storing unit, wherein the control unit is configured to prevent programming of the test information in the test information storing unit based on a control signal stored in the control signal storing unit.

2. The semiconductor memory device of claim 1, wherein the control unit is configured to generate a first control signal upon reception of a first command, store the first control signal in the control signal storing unit, and prevent the programming of the test information storing unit according to the stored first control signal upon reception of a second command.

3. The semiconductor memory device of claim 2, wherein the control signal storing unit includes a one time programmable (OTP) device, and the stored first control signal corresponds to a state in which the OTP device is programmed.

4. The semiconductor memory device of claim 2, wherein the control unit further comprises:

a verification unit configured to verify data stored in the memory cell array upon reception of a third command; a verification result storing unit configured to store verification results of the verification unit; and

a decision unit configured to decide whether to store the first control signal in the control signal storing unit based on at least one verification result stored in the verification result storing unit.

5. The semiconductor memory device of claim 4, wherein the decision unit is configured to store the first control signal in the control signal storing unit when a number of results corresponding to a failure among the at least one verification result is larger than a reference value.

6. The semiconductor memory device of claim 4, wherein the verification result storing unit includes a fail address memory configured to store an address corresponding to a defect contained in the memory cell array.

7. The semiconductor memory device of claim 2, wherein the control unit is configured to receive a command instructing an entry into a test mode and recognize the first and second commands in the test mode.

8. The semiconductor memory device of claim 1, wherein the test information storing unit includes an anti-fuse circuit.

9. The semiconductor memory device of claim 1, wherein the test information storing unit is configured to store information for replacing a defect contained in the memory cell array.

10. The semiconductor memory device of claim 1, wherein the test information storing unit is configured to store operation characteristic information of the semiconductor memory device, and the operation characteristic information includes at least one of timing information and voltage level information.

11. A memory module comprising:

at least one semiconductor memory device; and

a memory controller including a control signal storing unit and a test information storing unit, wherein the memory controller configured to store test information in a non-volatile manner, the test information based on a test result of the at least one semiconductor memory device, wherein the memory controller is configured to prevent

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programming of the test information in the test information storing unit based on a control signal stored in the control signal storing unit.

12. The memory module of claim 11, wherein the memory controller is configured to store a first control signal upon reception of a first command, store the first control signal in the control signal storing unit, and prevent programming of the test information storing unit according to the stored first control signal upon reception of a second command.

13. The memory module of claim 12, wherein the control signal storing unit includes an OTP device, and the stored first control signal corresponds to a state in which the OTP device is programmed.

14. The memory module of claim 12, wherein the memory controller further includes:

- a verification unit configured to verify data stored in the semiconductor memory device upon reception of a third command;
- a verification result storing unit configured to store verification results of the verification unit; and
- a decision unit configured to decide whether to store the first control signal in the control signal storing unit based on at least one verification result stored in the verification result storing unit.

15. The memory module of claim 14, wherein the verification result storing unit includes a fail address memory configured to store an address corresponding to a defect contained in the semiconductor memory device.

16. A method of operating a semiconductor memory device having a memory cell array including a plurality of memory cells, the method comprising:

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storing test information in a test information storing unit in a non-volatile manner, wherein the test information is based on test results of the plurality of memory cells; and controlling the semiconductor memory device by preventing programming of the test information in the test information storing unit based on a control signal stored in a control signal storing unit.

17. The method of claim 16, wherein controlling includes generating a first control signal upon a first command, storing the first control signal in the control signal storing unit, and preventing the programming of the test information storing unit according to the stored first control signal based upon a second command.

18. The method of claim 17, wherein the control signal storing unit includes a one time programmable (OTP) device, and the stored first control signal corresponds to a state in which the OTP device is programmed.

19. The method of claim 17, wherein controlling further comprises:

- verifying data stored in the memory cell array based upon a third command;
- storing verification results; and
- determining whether to store the first control signal in the control signal storing unit based on at least one stored verification result.

20. The method of claim 16, wherein the test information storing unit includes an anti-fuse circuit.

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